PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR MAY 1938

[Dependent alone on observations at Zurich and its station at Arosa]

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich Switzerland]

May 1938	Relative numbers	May 1938	Relative numbers	May 1938	Relative numbers
1	*Ec* 115	11	149	21	----------
2	134	12	*ad* 143	22	*a* ——
3	*EWaaacc* 160	13	151	23	*b*? 119
4	*aad* ——	14	*ad* 135	24	*Maac* 172
5	123	15	*a* 131	25	161
6	*a* 138	16	105	26	*Mc* 152
7	*d* 136	17	*Eac* 91	27	126
8	*EMccd* 153	18	*ad* 87	28	----------
9	*d* 156	19	95	29	*EMcc* 104
10	*bd* 151	20	*Eac* ——	30	89?
				31	*Eacd* 91

Mean, 26 days = 129.5.

Middle, large bright chromospheric eruption in central zone in May 24, observed at $16^h\ 05^m$ to $16^h\ 15^m$, C. G. T.

a = Passage of an average-size group through the central meridian.

b = Passage of a large group or spot through the central meridian.

c = New formation of a group developing into a middle-sized or large center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.

d = Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE In Charge]

By B. FRANCIS DASHIELL

The mean free-air data, given in table 1, based on 842 airplane and radiometeorograph observations made during the month of May 1938, includes the basic meteorological elements of barometric pressure (P), temperature (T), and relative humidity (RH), all recorded at certain geometric heights.

These "means," computed by the customary method of differences, are omitted when less than 15 observations have been made at the surface and less than 5 at a standard height. However, at those standard heights lying within the limits comprising the monthly vertical range of the tropopause, 15 or more observations are required. For further details, see "Aerological Observations", in the January 1938, MONTHLY WEATHER REVIEW.

Reference to chart I shows that departures of the mean *surface* temperature above normal during May 1938 were moderate, reaching 4° (F) over the northwestern and southeastern coastal regions, particularly western Washington and eastern Georgia. Elsewhere temperatures remained close to normal, being somewhat above throughout the southern States, entire Mississippi Valley and Pacific coast, and slightly subnormal in the northern Plains and Rocky Mountain States, the Ohio Valley and north Atlantic States.

The highest mean free-air temperatures for the month occurred over Maxwell Field, Ala., and Pensacola, Fla., at 0.5 and 1 kilometer; over El Paso, Tex., at 1.5 and 2 kilometers; over El Paso and Kelly Field, Tex., at 2.5 and 3 kilometers; over Kelly Field at 4 kilometers; and over Kelly Field and Pensacola, Fla., at 5 kilometers. The highest mean free-air temperature (20.8° C.) occurred over Maxwell Field, Ala., at 0.5 kilometer, while the lowest of the month was −15.7° C. over Lakehurst, N. J., at 5 kilometers. Elsewhere, the lowest temperatures for the month were recorded over Boston, Mass., at all levels, being equally over only Lakehurst, N. J., at 4 kilometers, and exceeded at 5 kilometers. Low temperatures also occurred over Sault Ste. Marie, Mich., at all levels, and at 3 and 4 kilometers along a belt extending across the northern tier of states. Billings, Mont., was colder at 4 and 5 kilometers (−14.7° C. at 5 kilometers) than any other station in this belt west of Boston, Mass., to the Pacific coast.

Mean free-air temperatures for May were seasonally higher in every case than during April. However, over Pensacola, Fla., at 4 kilometers, the temperature equaled that observed the preceding month, and at Boston, Mass., at 2 kilometers, and Lakehurst, N. J., at 2.5 kilometers, the mean was very little higher during May. The rest of the country was warmer than in April; this being outstanding at all levels over Sault Ste. Marie, Mich., and to a less marked degree over Fargo, N. Dak., and at 0.5, 1, 1.5, 2, 2.5, and 3 kilometers over Barksdale Field, La., and Maxwell Field, Ala. The greatest difference in May over April was noted at Sault Ste. Marie, Mich., at 1.5 kilometers (8.2° C.); over Fargo, N. Dak., at 0.5 kilometer (6.0° C.); over Barksdale Field, La., and Maxwell Field, Ala., at 1 kilometer (5.1° C. and 6.3° C., respectively). Smaller excesses occurred over Spokane, Wash., and Chicago, Ill., but at greater heights.

Isobaric charts, prepared from the mean barometric pressure in millibars, as shown in table 1, indicate that a statistical center of low pressure existed during the month over New England, having moved eastward from the position it occupied during April. Boston, Mass., showed the lowest mean pressure. But the area extended westward sufficiently to include Sault Ste. Marie, Mich., and Fargo, N. Dak., at all levels above 2 kilometers. A tendency toward low pressure existed also over the Pacific Northwest (Seattle, Wash.) at 0.5, 1, 1.5, and 2 kilometers. The

pressure generally was high over the southeastern States, particularly over Pensacola, Fla., at all levels. At 2.5 kilometers and up, pressures were uniformly distributed east and west, but increasing slightly toward the Gulf coast and Mexican border. During May pressures varied little from those recorded in April, except for a slight decrease at 0.5 kilometer, and increases at 2.5, 3, and 5 kilometers. Other levels remained about the same during both months.

Free-air relative humidity, as in April, remained lowest in the southwestern States, centering over El Paso, Tex., up to and including 3 kilometers; above that height the driest air was located over San Diego, Calif. Over the northeastern States, the humidity was moderately high at all levels up to 3 kilometers. At 4 and 5 kilometers, the humidity was highest over Salt Lake City, Utah, and Billings, Mont. Along the middle Atlantic coast, at all levels, the humidity was unusually low as compared with the areas to the west and north. Outstanding in this region was Washington, D. C., where the humidity was lower than for several months, at the higher levels. At 5 kilometers, over Washington, the humidity was found to equal the low humidities over El Paso and Kelly Field, Tex.

Free-air resultant winds, based on pilot-balloon observations made near 5 a. m. (75th meridian time) during the month of May, are shown in table 2. These resultant winds indicated, quite generally, nearly normal directions at all levels except over the northwestern portion of the United States. This was noticeable, particularly, over Medford, Oreg., at 1.5, 2, 2.5, and 3 kilometers, and Seattle, Wash., at 0.5, 1, 1.5, 2, and 4 kilometers. The resultant wind velocities at Medford and Seattle remained light. Elsewhere, outstanding departures from normal were confined to the standard levels immediately over the surface.

At Seattle, Wash., the resultant winds departed consistently by rotating in a clockwise direction north from normal at all levels above the surface. These directions at the standard levels from 0.5 to 4 kilometers, inclusive, were: 284°, 322°, 300°, 315°, 278°, 282°, and 337°, as compared to the normals of 205°, 235°, 236°, 248°, 242°, 253°, and 261°, respectively. However, in spite of this more northerly departure the resultant velocities at Seattle, Wash., showed only slight increases of approximately 1 m. p. s. up to 2 kilometers; they were equally less than normal at 2.5, 3, and 4 kilometers.

Somewhat similar conditions existed also over Spokane, Wash., Billings, Mont., Oakland, Calif., and, for a few levels, over Medford, Oreg. The departures at Spokane and Oakland, were not so marked as at Seattle, Wash. But, at Medford, Oreg., the largest departures at several consecutive levels in the United States occurred during the month at 1.5, 2, and 2.5 kilometers. The current resultant directions at those levels were 14°, 359°, and 352°, as compared to the normals of 79°, 243°, and 253°, respectively. At Spokane, Wash., moderate increases of velocity over the normal were recorded, but at Medford, Oreg., and Oakland, Calif., the resultant velocities varied only slightly from the normal.

Greatest departures from normal, other than those at Medford, Oreg., occurred at Sault Ste. Marie, Mich., at 1 kilometer. Here the current difference, rotated in a counterclockwise direction from normal, was 171°. Pensacola, Fla., showed a difference of 115° at 0.5 kilometer when rotated clockwise; and Fargo, N. Dak., rotated clockwise from normal, was 152° at 0.5 kilometer. Fairly stable conditions, with least departures at all levels, but less than normal when rotated counter-clockwise, existed over Detroit, Mich., during the month. At Boston, Mass. and Houston, Tex., *all* departures below 2.5 kilometers were slightly north of normal, while above that level they were south of normal. Elsewhere over the United States the winds were nearly normal at all levels. Resultant velocity departures exceeding normal were noticeable at Atlanta, Ga., and Sault Ste. Marie, Mich. But the greatest occurred over Newark, N. J., at 2, 2.5, and 3 kilometers. At 2.5 kilometers this departure was 6.8 m. p. s. A less-than-normal departure occurred over Fargo, N. Dak., at 4 kilometers. Of the resultant winds over the entire country during May, 20 percent showed an easterly component at 0.5 kilometer but diminishing steadily to only 4 percent at 2.5 kilometers, then becoming 100 percent westerly at and above 3 kilometers.

Table 3 shows the maximum free-air winds during May. At Huron, S. Dak., high wind velocities occurred. On the 12th a velocity of 54 m. p. s. was recorded at 10.2 kilometers, and again on the 13th the highest for the country, 57.6 m. p. s., occurred at 4.8 kilometers. Other high velocities existed over Albuquerque, N. Mex., and Modena, Utah.

TABLE 1.—*Mean free-air barometric pressures (P) in mb., temperatures (T) in °C., and relative humidities (R. H.), in percent, obtained by airplanes and radiometeorographs during May 1938*

Stations	Altitude (meters) m. s. l.																													
	Surface				500			1,000			1,500			2,000			2,500			3,000			4,000			5,000					
	Number of obs.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.		
Barksdale Field, La.[1] (52 m)	31	1,007	18.9	87	956	19.6	68	902	17.5	59	850	15.2	53	802	12.8	48	754	10.2	47	710	7.3	46	628	0.1	50						
Billings, Mont.[2] (1,090 m)	30	890	8.5	71							847	9.2	58	797	6.0	58	749	2.4	60	704	−1.3	65	620	−8.2	69	544	−14.7	63			
Boston, Mass.* (5 m)	18	1,011	10.0	81	952	8.4	77	896	6.1	76	843	3.2	74	792	0.5	72	744	−1.5	70	699	−3.7	67	614	−9.6	60	539	−15.5	59			
Cheyenne, Wyo.[2] (1,873 m)	29	809	6.4	79										797	7.7	69	749	5.2	67	705	2.3	64	621	−5.6	64	546	−13.4	63			
Coco Solo, C. Z.[3] (15 m)	25	1,009	25.0	91	954	23.8	88	902	21.5	87	851	18.9	87	802	16.6	81	756	14.3	75	712	11.7	72	631	5.8	70	559	−0.1	71			
El Paso, Texas[2] (1,193 m)	31	878	18.0	28							847	19.4	27	800	16.4	27	753	13.0	26	709	9.0	26	627	0.9	28	552	−6.9	32			
Fargo, N. Dak.[2] (274 m)	31	980	8.2	81	954	9.5	69	897	7.5	66	844	5.2	66	794	3.3	66	746	0.5	70	701	−2.0	66	616	−7.0	54	542	−12.8	53			
Kelly Field, Tex.[1] (206 m)	26	990	20.7	83	957	20.0	77	903	17.7	74	851	15.9	65	803	14.4	54	756	12.1	42	711	8.8	41	629	1.7	42	555	−5.9	39			
Lakehurst, N. J.[3] (39 m)	20	1,009	9.9	84	954	12.0	55	899	9.8	51	845	6.9	54	795	3.5	57	747	0.1	58	702	−3.1	56	617	−9.6	51	543	−15.7	42			
Maxwell Field, Ala.[1] (52 m)	28	1,009	20.4	80	958	20.8	61	905	18.1	59	852	15.0	58	804	12.0	52	756	9.1	47	712	6.2	46	629	0.0	41	555	−6.2	38			
Mitchel Field, N. Y.[1] (29 m)	29	1,010	10.9	84	955	11.0	68	899	9.4	61	846	7.4	60	797	4.9	66	748	2.8	62	704	0.0	62	620	−5.3	55						
Nashville, Tenn.[2] (180 m)	30	993	17.2	83	957	18.5	71	903	16.2	70	850	12.9	71	802	9.7	69	754	6.5	65	709	3.7	57	626	−1.8	48	552	−7.8	44			
Norfolk, Va.[2] (10 m)	16	1,013	16.1	89	957	18.2	56	903	15.2	55	850	11.6	59	800	7.9	65	752	4.7	64	708	1.7	56	624	−4.9	47	549	−11.1	40			
Oakland, Calif.[2] (2 m)	31	1,016	11.7	83	958	12.4	74	902	14.8	49	850	12.5	42	800	9.4	39	752	6.2	40	708	3.1	39	624	−2.9	38	550	−9.4	37			
Oklahoma City, Okla.[2] (391 m)	31	967	16.4	84	954	17.7	73	900	16.6	64	849	15.1	54	800	12.5	52	753	9.0	55	708	5.6	55	626	−1.0	60	551	−8.1	58			
Omaha, Nebr.[2] (300 m)	31	976	13.4	81	953	14.7	67	898	12.9	64	846	10.3	62	797	7.6	56	749	4.7	55	704	1.8	58	621	−4.4	57	547	−11.1	54			
Pearl Harbor, T. H.[3] (6 m)	31	1,016	21.5	81	960	20.5	77	905	17.7	84	853	15.2	84	804	13.4	76	757	12.4	58	713	11.0	42	632	7.8	25	560	2.4	30			
Pensacola, Fla.[3] (13 m)	30	1,015	19.7	92	959	20.4	70	906	18.5	58	854	15.8	51	805	12.9	47	757	9.8	44	713	7.1	39	629	0.6	40	556	−5.6	36			
St. Thomas, V. I.[3] (8 m)	30	1,017	26.5	71	961	21.8	84	907	18.2	86	855	15.8	77	806	13.6	68	759	11.2	62	714	8.6	58	633	3.6	50	559	−1.4	40			
Salt Lake City, Utah[2] (1,288 m)	31	869	9.2	70							848	11.7	54	798	9.2	52	750	5.7	55	706	1.8	61	622	−5.6	68	547	−12.7	65			
San Diego, Calif.[3] (10 m)	26	1,014	15.4	80	957	13.1	81	902	15.4	57	850	13.4	50	801	11.4	41	754	8.8	36	709	6.0	31	626	0.1	25	552	−7.1	23			
Sault Ste. Marie, Mich.[2] (221 m)	31	987	7.0	79	955	9.0	67	898	7.7	64	845	5.2	65	795	2.2	67	746	−0.7	68	701	−2.9	62	616	−8.1	54	542	−14.2	50			
Scott Field, Ill.[1] (135 m)	25	997	13.8	85	955	16.8	62	900	14.0	65	848	10.7	68	798	8.1	64	750	5.0	63	706	1.9	60	622	−4.0	48	549	−10.4	44			
Seattle, Wash.[2] (10 m)	23	1,019	14.7	59	961	11.1	61	905	9.3	54	852	6.9	46	801	4.5	37	753	1.6	37	708	−1.4	34	623	−7.8	32						
Selfridge Field, Mich.[1] (177 m)	29	992	10.0	83	955	11.3	71	899	9.4	70	846	6.9	67	796	4.1	67	748	1.4	64	703	−1.3	60	618	−6.9	52	544	−13.5	51			
Spokane, Wash.[2] (597 m)	31	945	8.7	69				901	12.0	48	848	9.7	45	798	6.0	49	750	2.3	55	705	−1.2	59	620	−7.8	63	545	−13.8	61			
Washington, D. C.[3] (13 m)	29	1,014	13.8	76	956	14.0	59	902	12.0	57	849	8.8	60	799	6.1	57	751	3.4	48	706	0.4	49	622	−5.6	39	547	−11.9	35			
Wright Field, Ohio[1] (244 m)	27	985	11.7	85	956	13.6	72	900	12.1	68	848	9.5	69	798	6.6	69	750	4.2	63	706	2.0	51	622	−4.0	49	548	−10.1	46			
Burbank Calif.* (220 m)	31	988	11.4	82	956	13.0	70	901	14.0	52	849	12.0	47	800	9.8	42	753	7.5	36	708	5.0	34	626	−0.6	29	551	−7.3	26			
Chicago, Ill.[2] (187 m)	31	991	11.8	82	954	12.6	70	899	10.4	68	846	7.8	65	796	5.5	61	748	2.8	58	704	0.2	60	620	−6.0	54	545	−12.3	47			

Observations taken about 4 a. m. 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.
*Observations by radiometeorograph. Stations not so marked have observations by airplane.

[1] Army.
[2] Weather Bureau.
[3] Navy.

NOTE.—None of the means included in this table are based on less than 15 surface or 5 standard-level observations.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during May 1938*

[Wind from N=360°, E=90°, etc.]

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (309 m)		Billings, Mont. (1,088 m)		Boston, Mass. (15 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cincinnati, Ohio (157 m)		Detroit, Mich. (204 m)		Fargo, N. Dak. (283 m)		Houston, Tex. (21 m)		Key West, Fla. (11 m)		Medford, Oreg. (410 m)		Nashville, Tenn. (194 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	319	1.9	271	1.3	285	1.9	321	1.5	283	2.6	195	0.4	200	0.1	229	0.7	360	0.7	125	1.2	123	2.2	184	0.3	203	1.4
500			269	4.0			314	3.9			227	2.3	220	2.5	235	2.2	333	1.1	162	6.2	125	4.0	253	0.4	236	4.5
1,000			270	6.1			298	4.6			247	3.8	267	5.0	267	4.1	308	1.6	169	5.6	135	3.5	331	1.8	260	5.9
1,500			273	6.2	287	3.8	294	7.1			253	4.7	264	6.4	271	3.8	284	1.3	170	3.4	142	1.8	14	1.6	264	6.9
2,000	298	3.7	270	6.3	294	4.1	293	7.7	288	3.2	278	6.0	255	6.9	280	4.3	261	1.8	205	3.6	142	1.4	359	1.4	252	7.4
2,500	285	4.8	275	6.6	291	5.3	283	8.5	282	3.9	277	6.7	271	7.1	272	5.1	290	3.9	242	2.0	158	1.0	352	1.2	259	7.0
3,000	278	6.1	267	7.4	294	6.5	280	9.8	283	6.7	287	8.7	256	5.5	283	5.2	299	2.9	266	1.8	224	1.4	324	2.3	262	6.0
4,000	265	9.2	249	4.5	282	8.2	280	12.0	292	8.1			245	7.4	277	6.9	347	0.6	289	3.9	261	4.7	290	3.6	291	5.7
5,000	265	11.2			299	3.0			261	7.6					286	10.4			283	6.0	267	4.2	263	6.2		

Altitude (meters) m. s. l.	Newark, N. J. (14 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Pearl Harbor, Territory of Hawaii[1] (68 m)		Pensacola, Fla.[1] (24 m)		St. Louis, Mo. (170 m)		Salt Lake City, Utah (1,292 m)		San Diego, Calif. (15 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Spokane, Wash. (603 m)		Washington, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	334	1.2	246	1.2	164	2.5	180	0.7	50	2.4	291	1.2	193	1.1	151	2.5	27	0.9	78	1.4	142	1.3	122	0.7	304	0.8
500	323	4.5	284	1.7	162	4.3	202	1.1	61	5.2	235	2.3	226	4.3			336	2.3	110	3.6	284	0.3			319	3.8
1,000	312	5.5	341	4.3	200	8.4	240	2.0	70	4.1	224	3.3	257	6.0			339	3.6	120	1.2	322	1.6	243	3.1	310	3.9
1,500	296	8.3	7	4.4	224	6.5	255	3.4	83	2.7	230	3.3	268	6.9	154	2.4	329	2.8	247	1.2	300	1.6	257	4.6	293	6.7
2,000	289	12.3	354	4.4	250	7.3	281	4.7	179	1.1	195	3.1	271	7.3	259	1.3	304	2.7	247	2.4	315	2.4	263	4.3	283	8.8
2,500	285	16.2	336	4.8	253	7.1	289	5.3	216	1.8	223	1.7	262	7.1	283	2.4	281	3.8	290	2.9	278	3.0	273	4.0	271	10.2
3,000	278	14.8	342	7.0	264	5.4	289	5.6	224	1.5	250	1.1	250	6.1	282	3.9	322	5.1	306	5.5	282	2.9	263	3.4	263	10.5
4,000			329	7.2	302	7.7	298	6.6	270	0.3	266	4.3	296	6.3	273	6.8			310	9.2	337	4.6	272	4.7	279	9.1
5,000					303	10.7			284	3.7			301	5.0	279	10.5							266	7.6		

[1] Navy stations.

TABLE 3.—*Maximum free-air wind velocities (meters per second) for different sections of the United States based on pilot-balloon observations during May 1938*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station
Northeast [1]	40.4	NW	2,440	17	Newark, N. J.	40.4	NW	3,600	2	Albany, N. Y.	35.2	NW	5,940	1	Albany, N. Y.
East-Central [2]	36.1	SW	1,870	23	Cincinnati, Ohio	42.4	NW	4,680	16	Greensboro, N. C.	36.2	N	10,440	31	Greensboro, N. C.
Southeast [3]	32.0	W	2,260	15	Jacksonville, Fla.	38.0	W	3,640	14	Atlanta, Ga.	35.2	WNW	9,280	14	Key West, Fla.
North-Central [4]	30.5	WSW	1,320	2	Bismark, N. Dak.	57.6	WSW	4,800	13	Huron, S. Dak.	54.0	N	10,200	12	Huron, S. Dak.
Central [5]	34.7	S	970	4	St. Louis, Mo.	38.0	NW	3,140	15	St. Louis, Mo.	36.8	W	6,460	8	Wichita, Kans.
South-Central [6]	29.7	S	1,360	3	Brownsville, Tex.	29.1	SSW	3,730	3	Amarillo, Tex.	39.4	NNW	10,660	26	Del Rio, Tex.
Northwest [7]	26.8	WSW	2,160	12	Pendleton, Oreg.	33.5	NW	3,970	13	Missoula, Mont.	47.0	W	7,340	30	Medford, Oreg.
West-Central [8]	37.5	SSW	2,280	18	Modena, Utah	41.4	NW	4,780	2	Sacramento, Calif.	52.8	WSW	8,420	19	Modena, Utah.
Southwest [9]	32.8	WSW	2,300	12	Havre, Mont.	34.4	NW	4,700	4	Fresno, Calif.	55.0	WSW	6,500	1	Albuquerque, N. Mex.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in charge]

By BENNETT SWENSON

Precipitation during May 1938 was above normal in practically all sections, except the Southwest and extreme West. Kansas and Minnesota received more than twice the normal amount, and in the Ohio Valley and most of the Great Plains the rainfall was substantially above normal. Severe local flooding resulted principally in the rivers which drain the Kansas and Minnesota regions.

Upper Mississippi Basin.—High water prevailed over much of this section during the month. This was due to two distinct periods of heavy rains over Minnesota, Iowa, and Wisconsin during May 2–9 and May 14–28. In the first period the heaviest rainfall was centered north of the Twin Cities in Minnesota. This resulted in abnormally high lake levels and caused disastrous flood conditions in the Aitken County area in Minnesota. The report on the floods in this area was not received in time for inclusion in the May issue of the REVIEW, but will be included in the next issue.

The following report was submitted by the official in charge of the La Crosse, Wis., district, which consists of the Mississippi River and tributaries from below St. Paul, Minn., to and including La Crosse:

High water prevailed during the entire month of May in the district. The highest stage at La Crosse since April 1922 occurred when the crest reached 13.7 feet, although the crest in March 1936 was only 0.1 foot lower. Practically the same relative differences prevailed at Winona, Minn., for those years. In the upper section of the district from Lake Pepin to Hastings, Minn., the flood conditions were comparable to 1922, and crest stages averaged only 0.3 to 0.4 foot lower than in that year. The high water in May 1938 was characterized by two gradual rises covering the periods 1–13 and 18–27. During the first period the average rise was 5.0 feet and during the second period 1.2 feet throughout the district. The second rise was really a secondary crest produced by additional heavy rains just after it had begun to fall after the first period of prolonged rains.

The present occurrence of high water was by no means due to melting snow in the headwaters, as the crest resulting from this run-off appeared throughout the district from March 26 to March 31. It was due wholly to two distinct periods of heavy rains extending from the 2d to the 9th and from the 14th to 28th. The first of these periods resulted in a large reserve of water in the section north of the Twin Cities, resulting in turn in abnormally high lake levels and causing disastrous flood conditions in the Aitken, Minn., area. The May totals of rainfall show an unusual condition in that the amounts increased from La Crosse northward. The reverse is generally the case, larger amounts occurring in the southern section of the district. The following May rainfall totals will indicate this as well as to show that the amounts vary in excess of normal amounts from +1.11 inches at La Crosse to +7.28 at Hastings: La Crosse, 4.86; Dam No. 7, 5.90; Hatfield, 5.75; Dam No. 6, 4.87; Winona, 6.87; Dam No. 5A, 8.24; Beaver, 4.52; Dam No. 5, 6.12; Dam No. 4, 7.11; Durand (Chippewa), 9.41; Reads, 8.52; Red Wing, 9.20; Dam No. 3, 9.38; Hastings, 10.95. The lower Chippewa Valley had as large an excess as the vicinity of Hastings, and the Chippewa River contributed materially to high-water stages from Reads, Minn., southward, especially in the secondary crest occurring at Winona and La Crosse on the 24th. The Chippewa at Durand, Wis., discharged slightly over 50,000 second-feet at the flood stage of 11 feet on the 7th and 21st. The Black River contributed materially to flood stage at La Crosse on the 24th and 25th, caused by the release of a large volume of water from the Hatfield power dam.

The flood conditions in the Dubuque, Iowa, district, comprising the Mississippi River and tributaries from below La Crosse, Wis., to and including Dubuque, are reported by the official in charge at that place:

The Mississippi was unusually high for May, the average stage at Dubuque being 13.2 feet. There were two separate rises, the second beginning 5 days after the occurrence of the first crest. The river was falling at the beginning of the month, the lowest stage, 9.19, being reached in the afternoon of the 4th. It then began to rise due to general high-water conditions throughout the upper Mississippi Valley. The Wisconsin River crest passed downstream before the arrival of the upper Mississippi crest, and thereby reduced the severity of this rise at points near and below the mouth of the Wisconsin River. The crest gave a stage of 15.7 feet at Dubuque on the 20th. Further substantial rains, particularly in northern Wisconsin, produced new floods in many of the tributaries above La Crosse. In this case the times of arrival of crests from above La Crosse and from the Wisconsin River bore normal relations to each other, which favored somewhat higher stages than in the case of the preceding crest. An additional factor was the occurrence at Dubuque of still further heavy rainfall on the 27th. The final result was a crest of 17.15 feet on May 30. This was the highest river stage at Dubuque since April 1922.

The approach of the crest in the extreme upper Mississippi, together with further local heavy rains, caused the lower half of the upper Mississippi to slightly exceed flood stage, principally from Quincy to Alton, Ill., during the last few days of the month. Low places along the river were overflowed but only slight damage occurred.